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Gyrodontium sacchari (Spreng.: Fr.) Hjortstam (Boletales, Basidiomycota) in America: New records and its geographic distribution

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ABSTRACT: *Gyrodontium sacchari* (Spreng.: Fr.) Hjortstam is reported from two new areas of northwest and northeast Argentina, Brazil, and French Guiana. A geographic distribution map of the species in America and a discussion on its pattern of distribution are presented.

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Gyrodontium sacchari (Spreng.: Fr.) Hjortstam is a peculiar species in the Coniophoraceae Ulbr. characterized by a pileate basidiome, rarely resupinate, with a tuberculate to hydnoid hymenophore in olive green shades, simple-septate hyphae, and small, smooth, thick-walled, yellowish-brown, dextrinoid and cyanophilous basidiospores (Hjortstam 1995). *Gyrodontium* Pat. was erected with *Hydnum henningsii* Bres. (1890) as the generic type species, a later synonym of *Hydnum sacchari* Spreng.: Fr. (1820) originally described from Guadeloupe. A list of synonyms was provided by Hjortstam (1995). The species has been reported to have a mainly pantropical distribution with records in America (Table 1), Africa (Hjortstam 1987; Carlier *et al*. 2004) and Australasia (Carlier *et al*. 2004; Dai 2011; May *et al*. 2003). However, it was reported also from subtropical and temperate areas in both hemispheres, in America (Valenzuela *et al*. 2012), Europe (Bernicchia *et al.* 2007), Africa (Reid 1963), and Asia (Sato *et al*. 2010).

The distribution of *G. sacchari* in America is based on a limited number of published records spread over the literature that are summarized in Table 1. Besides Guadeloupe, the type locality, the species is known from Cuba, Brazil, French Guiana, Argentina, and Ecuador (Maas Geesteranus 1966; Bononi 1988; Hjortstam 1995; Carlier *et al*. 2004; Wright and Wright 2005; Læssøe and Petersen 2008). Recently, it was reported from Mexico (Valenzuela *et al*. 2012), the northernmost record for the taxon.

In this work we report three new records for the species from northern Argentina and one from northeastern Brazil. We present a geographic distribution map of the species with a discussion of its distribution pattern.

The first record of *G. sacchari* in Argentina was published by Wright and Wright (2005) based on a collection dating back from 1981 [BAFC 27421, identified as *G. flavidum* (Lloyd) D.A. Reid], and originating from Iguazú National Park, particularly in the "Plaza de los Boyeros" Lower Circuit, a locality that no longer exists. Recently, the species was found further south, in the locality of Leandro N. Alem, Misiones [Argentina, Misiones, Leandro N. Alem, inside of a decayed, dead, fallen hollow trunk of an angiosperm, 14 July 2013, 27°39′12″ S, 55°20′10″ W, 290 m a.s.l. (above sea level), *E.M. Giorgio 20* (CORD)] (Figure 1A–D). Both collections originated from Atlantic Rain Forest areas. We discovered another specimen in the Yungas Mountain Rain forests of NW Argentina [Argentina, Salta, Anta, El Rey National Park, dead fallen trunk of an angiosperm, 8 March 2005, 24°43′1.5″ S, 64°38″51.5″ W, 886 m a.s.l., *Robledo 511 & 520* (CORD), from the same individual]. Both types of rain forests are distributed in tropical South America, reaching their southern limits in subtropical northern Argentina.

Despite extensive fungal diversity surveys of Brazilian ecosystems in the last few years (*e.g.*, Drechsler-Santos *et al.* 2008, 2009; Baltazar and Gibertoni 2009; Gomes-Silva and Gibertoni 2009; Gibertoni and Drechsler-Santos 2010; Gugliotta *et al.* 2010; Cortellini Abrahão *et al.* 2012), reports of *G. sacchari* remain scarce. The species was previously known from the Atlantic rain forests in the east coast of Brazil, where it has been reported from the states of Bahia (Maas Geesteranus 1966) and Rio Grande do Sul (Bononi 1988) (Table 1). The most recent updated description of the species is based on Hjortstam's specimen *Hjm 16481* (Hjortstam 1995) [Brazil, Sao Paulo state, Parque Estadual Fontes do Ipiranga, on 16–24 January 1987, K(M) 192677]. More recently, one of us (CF) recorded the species in the

Table 1. American records of *G. sacchari* on which the geographic distribution map is based. Herbarium acronyms are according to Thiers (2014).

COUNTRY PROVINCE/STATE, LOCALITY *VOUCHER*	ECOSYSTEM – SUBSTRATE	REFERENCE
Argentina		
Salta Province, Anta Department, El Rey National Park, *Robledo 511 & 520* (CORD)	Yungas Mountain forests – dead fallen tree trunk of undet. angiosperm	This work
Misiones Province, Leandro N. Alem Department, Leandro N. Alem, *E.M. Giorgio 20* (CORD)	Atlantic Rain forest – inside of a highly decayed dead fallen hollow tree trunk of undet. angiosperm	This work
Misiones Province, Iguazú Department, Iguazú National Park, BAFC 27421	Atlantic Rain forest – n/d	Wright and Wright (2005)
Belize		
P.J. Roberts B222 (K108789)	n/d – on fallen palm	e-K
Brazil		
Sao Paulo state, Parque Estadual Fontes do Ipiranga, *HJM 16481*, K(M) 192677	Atlantic Rain forest – n/d	Hjortstam (1995)
Sergipe state, São Cristóvão	Atlantic Rain forest – Inside a hole of living tree	This work
Bahia state	n/d	Maas Gesteranus (1966)
Rio Grande do Sul state, Lageado, Guaiba and Pareci	n/d	Bononi (1988) (Three highly nearby locations marked with one dot on the map)
Costa Rica		
Heredia Province, Sarapiqui, La selva Biological Station, *Obrevo 2084 & 2128* (NY)	n/d – Dead snag	e-NY
Cuba		
T of *Hydnum clavarioides* Berk. & M.A. Curtis, *Wright 238* (K 67830)	n/d – Dead wood	Hjortstam (1995)
Ecuador		
Orellana Province, Tiputini Field Station, *TL-11471*	n/d	Læssøe and Petersen (2008)
French Guiana *		
Cacao Area, Plateau K (MUCL 42726)	Tropical rain forest – Fallen trunk undet. angiosperm	Carlier *et al.* (2004)
Nouragues Natural Reserve (MUCL 54404)	Tropical Rain Forest – Base of living tree, undet. angiosperm	This work
Guadaloupe		
T of *G. sacchari* (UPS)	n/d – Leaves of sugar cane	Hjortstam (1995)
Mexico		
Sonora state, Municipality of Álamos, Palo Injerto, *Valenzuela 13068* (ENCB, CESUES)	n/d	Valenzuela *et al.* (2012)
Panama		
Panama Province, La Chorrera District, La Chorrera	n/d – Stem of dead trees	MO

T= holotype, n/d= no data, e-K= K online database at http://apps.kew.org/herbtrack/search, e-NY= C.V. Starr Virtual Herbarium of NYBG at http://sciweb.nybg.org/science2/VirtualHerbarium.asp, MO = Record at Mushroom Observer (http://mushroomobserver.org/97700?q=1rws8), additional data on substrate were provided by the collector E. Esquivel, * the two records in French Guiana are marked with one dot on the map.

hole of a dead fallen log of an undetermined hardwood (Figure 2A), in the locality of Tujubeba (10°56′04.3″ S, 37°11′12.2″ W), São Cristóvão, Sergipe state. This area contains remnants of Atlantic Rain Forest in the Brazilian coastal plains. Even though the material could not be properly conditioned to be kept as voucher specimen, we have the photographic record (Figure 2A). On a return trip to that place to find the specimen again, we found a dam instead (Figure 2B).

Based on all records available in the literature (Table 1), we present a preliminary distribution map of *G. sacchari* in America (Figure 4). Included are two records from Costa Rica and Belize, where the species is purported present based on herbarium records available at the virtual online herbaria K and NY. These herbarium specimens were identified by experienced mycologists (Table 1) and, although we did not study these materials and confirm their identity, we included them because they constitute evidence and possible hypothesis of the species distribution.

Gyrodontium sacchari seems to be distributed throughout Central America and the Caribbean region as well as northern coastal areas of South America (circled area in Figure 4). From this central area, the species appears to have spread northward and southward reaching subtropical areas in both hemispheres (as indicated by arrows in Figure 4). The presence in Northern Mexico was recently reported from Sierra de Álamos, Río Cuchujaqui Biosphere Reserve, which is region with diverse ecosystems including xerophilous scrub, tropical deciduous forest and oak-pine forest (Valenzuela *et al.* 2012). However, there is no information on the ecosystem and/or substrate on which *G. sacchari* was collected, except for altitude, 425 m a.s.l., making it difficult to explain this occurrence in its distribution.

Regarding the distribution in South America, *G. sacchari* spans over the Atlantic Rain Forest reaching northeast Argentina to the south. The southernmost limit of distribution seems to be at 30°S near Porto Alegre (Guaiba locality, Table 1). Probably, *G. sacchari* continues to the north

Figure 1. A–D. Macroscopical features of *Gyrodontium sacchari* (EM Giorgio 20 CORD). A) Detail of the pilear surface. B) General view *in situ*. C) Detail of the hymenial surface. D) General view of hymenial surface. Photos by E. M. Giorgio.

connecting with the central distribution area, either along the coast or through the islands and remnants of Atlantic forest occurring in the Caatinga (blue arrow with "?" in Figure 4), but records are needed to confirm this hypothesis. The new record in the Argentine Yungas is not surprising considering the presence of the species in Ecuador. Yungas forests are characterized by the presence of particular floristic elements of different origins and constitute an Andean corridor for several fungal species [see Robledo and Rajchenberg (2007) for a discussion]. *Gyrodontium sacchari* could follow this corridor, as previously shown for other species (Robledo *et al.* 2006; Amalfi *et al.* 2014). Future collecting could reveal the presence of *G. sacchari* along the distribution of Yungas forest in Bolivia, Peru, Colombia, and Venezuela. Alternatively, its distribution following the Atlantic Rain Forests and Yungas forest (blue arrows in Figure 4) might suggests NSDF (Neotropical Seasonal Dry Forests) (Prado 2000; Pennington *et al.* 2000) as a possible explanation of the distributional pattern; in which case, the species should be present in some intermediate areas in Paraguay. This idea has been previously suggested as a way to understand distributions of other fungal species by Romero *et al.* (2012).

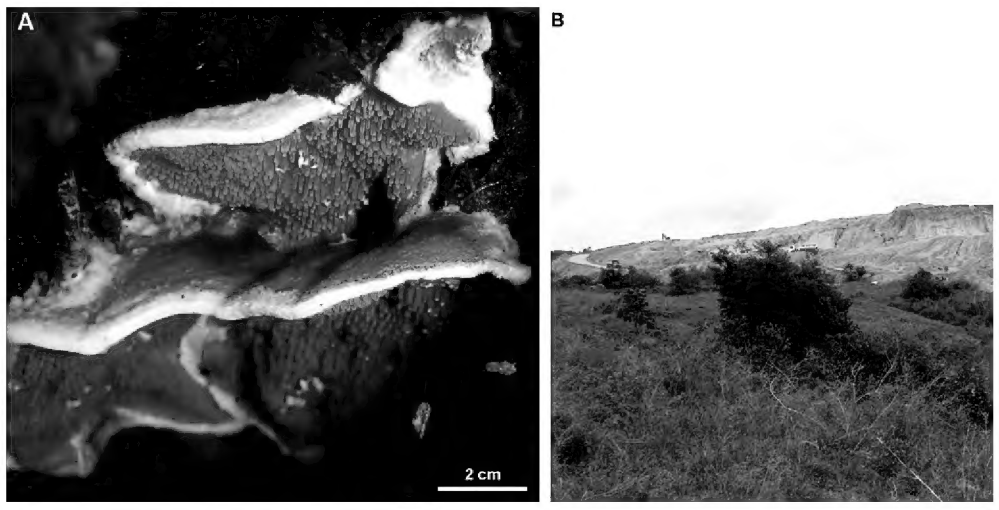

Figure 2. A–B. Macroscopical features and habitat of *Gyrodontium sacchari* recorded in Sergipe Brazil. A) Close up of the basidiome in situ, showing the typical hymenophore and the brownish spore print in the pilear surface. B) Area of previous record, where a dam is under construction today. Photos by C. Franco.

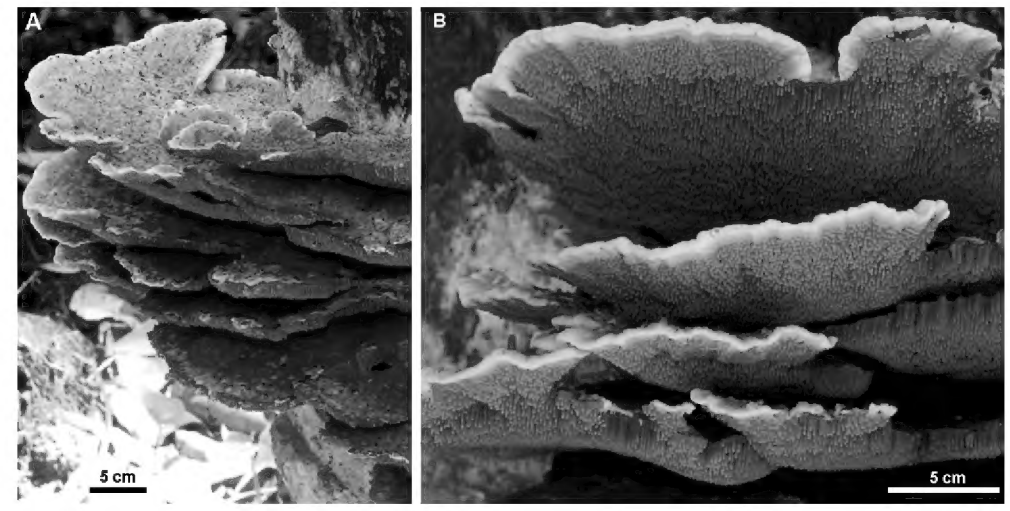

Figure 3. A–B. Macroscopical features and habitat of *Gyrodontium sacchari* recorded in French Guiana (MUCL 54404. A) General view *in situ*, note the brownish spore print in the pilear surface. B) Close up of the hymenophore, showing the white sterile margin. Photos by C. Decock.

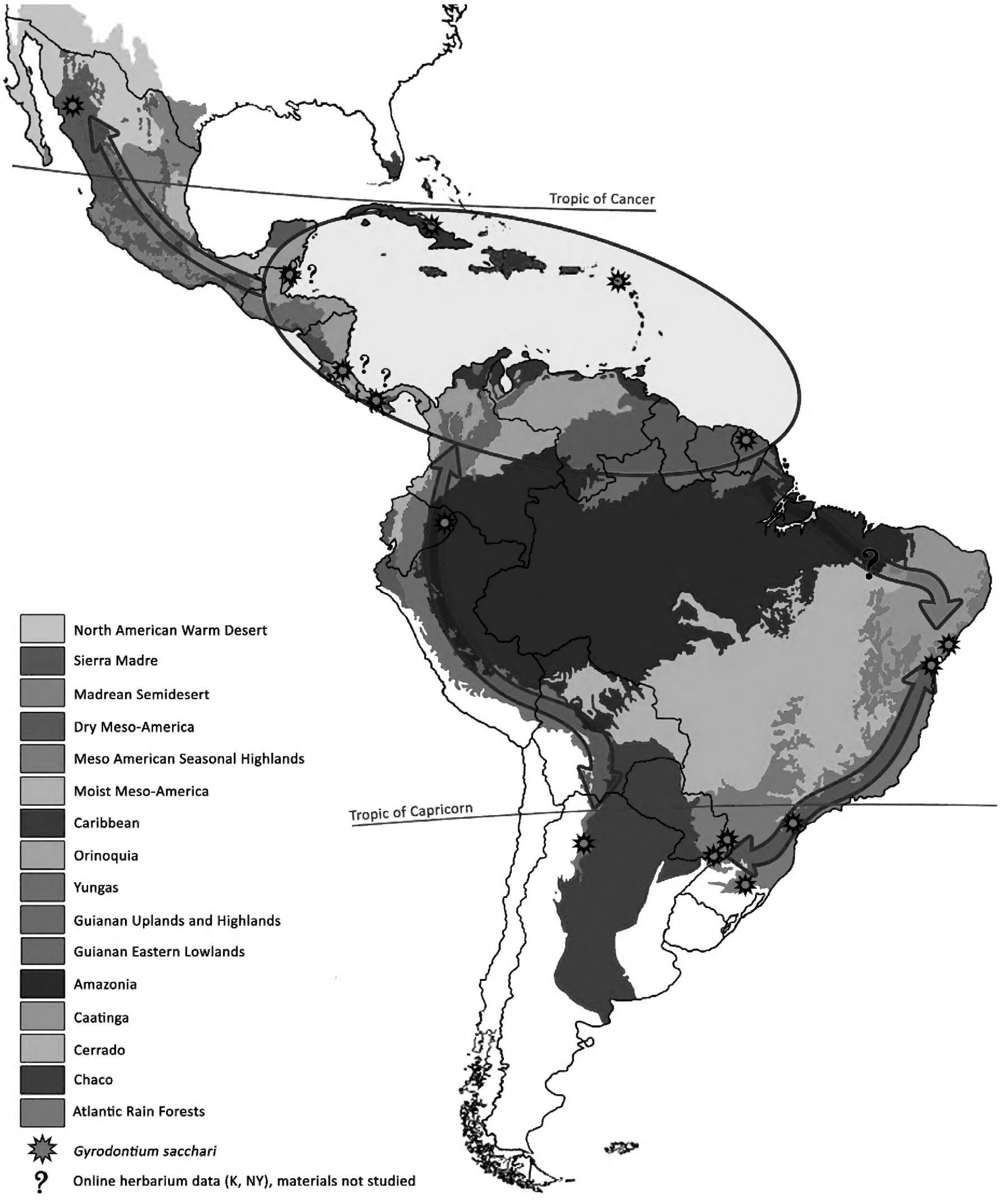

Figure 4. Distribution map of *Gyrodontium sacchari* based on records from Table 1. Main Eco-regions of America are shown. Shaded area indicates the main distribution in Central America. Arrows indicate potential distribution routes, see discussion in the text.

The present distribution of *G. sacchari* illustrated in Figure 4 may not represent its actual distribution in America, but possibly reflects areas of intense collecting efforts. Despite sampling effort being far from enough in South America, the relatively few records throughout the distribution area could, in fact, reflect a more restricted distribution pattern.

Based on our field experience, it appears that basidiomata are produced irregularly and/or they are ephemeral. For example, after about 10 years of field work in French Guiana, CD found only two specimens. In the last 4 years, walking repeatedly along the same path in the Nouragues Natural Reserve, only once we encountered basidiomata of *G. sacchari* on a big living tree by the side of the track [French Guiana, Municipality of Regina, Réserve Naturelle des Nouragues, CNRS Inselberg station, track (layon) C.I., on the way to the Nouragues inselberg, trunk of living tree, unidentified angiosperm, 120 m a.s.l., July 2012, *Decock* MUCL 54404] (Figure 3A–B). Basidiomata were not observed along the path the year before; and checking the same tree yearly for another two years, basidiomata were no longer observed. The species may require specific ecological conditions to produce basidiomata.

Considering the local conditions where the species had been collected, it could be predicted that the species would be expected in other areas of similar conditions, though endemism also exists at local scale. In the case of *G. sacchari,* considering its wide distribution through the Neotropics, its mycelia might be potentially present everywhere (where the environmental conditions in a broad sense exist), while fructifications are more unpredictable.

The species is mostly found inside the hollowed out heartwood of decaying dead tree trunks. This may be one of the reasons why the species has been overlooked. However, as previously mentioned, it has also been reported on living trees. It is interesting to note that the type collection is the only record on leaves of sugar cane (*Saccharum officinarum* L.), a monocotyledonous plant. We can infer that it was growing on a pile of leaves and bagasse waste, and not over leaves of standing plants. It was also found on a wooden pole from a stilt house in a human made environment in French Guiana.

Finally, it cannot be excluded that "cryptic" species are involved. At a global scale *G. sacchari* has been reported from a wide range of substrates and ecosystems, *e.g.,* on living *Pinus* sp. in Italy (Bernicchia *et al.* 2007) and trunks of *Pinus luchuensis* Mayr. in Bonin Islands (Sato *et al.* 2010). It has been shown that a large number of cryptic species occur in *Coniophora* DC. (a phylogenetic sister clade of *Gyrodontium*), that were not detected based on morphological characters (Kauserud *el al.* 2007). A similar situation could occur with *Gyrodontium* in South America, which has a wide distribution encompassing varied ecological systems, *e.g.,* Caribbean, Atlantic Rain forest, Andean corridor.

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